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Adhesion Hysteresis and Its Role in Vibrothermography Crack Heating

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Vibrothermography is an NDE inspection which uses vibration to stimulate surface cracks and measure the resultant heat generation. For years, the accepted assumption has been that heat generation in Vibrothermography NDE is due to friction between opposing crack surfaces [1–3]. A frictional mechanism suggests that crack surfaces in sliding shear would generate heat, whereas crack surfaces coming into and out of contact in an opening-closing mode would not, or would generate much less. But cracks heat easily in opening/closing mode and experimental evidence [4] is not consistent with the prediction that heat generation for shear vibration should be substantially larger than heat generation for opening-closing mode. Perhaps friction is not the dominant heating mechanism or is not the entire story. Recent experiments [5–7] have led to several observations regarding the behavior of heat generation at cracks: i) a linear dependence on excitation frequency, ii) a dependence on excitation amplitude somewhere between linear and quadratic, iii) Crack heating occurs at or near the closure point where the crack transitions from closed (crack faces in contact) to open (crack faces not in contact) We revisit the controversy over the underlying mechanism of vibrothermographic crack heating, evaluating various alternative theories, including linear absorption, irreversible thermoelasticity, friction, adhesion hysteresis, and plastic flow for consistency with the experimental evidence. We conclude only adhesion hysteresis (for opening/closing mode or sliding) and friction (for sliding mode only) are consistent with experiment.

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